

## METHOD FOR FABRICATING SEMICONDUCTOR DEVICE

### BACKGROUND OF THE INVENTION

The present invention relates to methods for fabricating a semiconductor device,  
5 and more particularly relates to a method for forming an interconnect of a semiconductor  
device.

In recent years, copper has been commonly used as an interconnect material for  
semiconductor devices. In process steps for processing an interconnect formed by using  
copper as an interconnect material, used is a damascene process in which an interconnect  
10 groove is formed by a dry etching technique and then an interconnect material is filled into  
the interconnect groove (see, e.g., Japanese Unexamined Patent Publication No. 2001-  
196371).

Hereinafter, a method for forming an interconnect in a known semiconductor  
device will be described with reference to the accompanying drawings.

15 FIGS. 8A through 8D are cross-sectional views illustrating respective process steps  
for fabricating a known semiconductor device.

First, as shown in FIG. 8A, a silicon oxide film 102 is formed on a semiconductor  
substrate 101 of silicon and then an interconnect groove is formed in the silicon oxide film  
102. Next, a conductive pattern 103 of copper is formed so as to be filled in the  
20 interconnect groove formed in the silicon oxide film 102. Subsequently, an insulating film  
104 is formed on the silicon oxide film 102 and the conductive pattern 103, and then a  
resist pattern 105 having an opening 105a is formed on the insulating film 104.

Next, as shown in FIG. 8B, the insulating film 104 is etched by plasma dry etching  
using the resist pattern 105 as a mask to form an opening 104a in the insulating film 104.  
25 In this manner, the surface of the conductive pattern 103 is exposed. The plasma dry

etching is performed using a parallel plate RIE system under the conditions where the flow rate of a  $\text{CF}_4$  gas as an etching gas is 50 mL/min (normal state), the flow rate of an  $\text{O}_2$  gas as a control gas for a deposit to be etched is 10 mL/min (normal state), the substrate temperature is 25  $^{\circ}\text{C}$ , the RF output power is 1000 W, and the inside chamber pressure is 5 Pa.

Next, as shown in FIG. 8C, ashing using an oxygen gas is performed to remove the resist pattern 105. The ashing is performed using a microwave plasma ashing system under the conditions where the flow rate of an oxygen gas is 1000 mL/min (normal state), the microwave output power is 2000 W, the discharge time is about 1 minute, the substrate temperature is about 250  $^{\circ}\text{C}$  and the pressure is about 100 Pa. By the ashing, a copper oxide layer 103a having a thickness of about 40 nm is formed on the surface of the conductive film 103.

Next, as shown in FIG. 8D, the copper oxide layer 103a which has been formed during the ashing is removed by cleaning using an organic acid cleaning agent containing aluminum fluoride, and Ar sputtering. Thereafter, a conductive film 106 is formed on part of the conductive pattern 103 from which the copper oxide layer 103a has been removed and the insulating film 104.

In the method for fabricating a known semiconductor device, however, the thickness of the copper oxide layer 103a formed on the surface of the conductive pattern 103 is about 40 nm. That is to say, the copper oxide layer 103a is relatively thick. Accordingly, the copper oxide layer 103a can not be entirely removed by an organic acid cleaning and Ar sputtering, and thus the copper oxide layer 103a is left between the conductive pattern 103 and the conductive film 106, as shown in FIG. 8D. This results in an increase in contact resistance between the conductive pattern 103 and the conductive film 106 or variations in contact resistance therebetween the conductive pattern 103 and

the conductive film 106.

## SUMMARY OF THE INVENTION

The present invention aims to prevent the progress of oxidation of a conductive pattern in removing a resist pattern and also to prevent the formation of a thick oxide film which is difficult to be removed on the surface of the conductive pattern.

To solve the above-described problems, a first method for fabricating a semiconductor device according to the present invention is characterized by comprising the steps of: forming an insulating film on a conductive pattern formed on a substrate; forming 5 a resist pattern on the insulating film; performing etching to the insulating film using the resist pattern as a mask to form in the insulating film an opening at which part of the surface of the conductive pattern is exposed; forming an antioxidant layer on the part of 10 surface of the conductive pattern exposed while removing the resist pattern; and depositing a conductive film on the conductive pattern from which the antioxidant layer has been 15 removed.

In the first method for fabricating a semiconductor device, an antioxidant layer for preventing oxidation of an conductive pattern is formed on the surface of the conductive pattern while a resist pattern is removed. Thus, it is possible to prevent the progress of 20 oxidation of the conductive pattern in removing the resist pattern and also to prevent the formation of a thick oxide film which is difficult to be removed. Moreover, the antioxidant layer formed on the surface of the conductive pattern can be removed in a simple manner, and thus it is possible to prevent an oxide film from being interposed between the 25 conductive pattern and the conductive film. Therefore, the contact resistance between the conductive pattern and the conductive film can be reduced and variations in the contact resistance therebetween can be suppressed.

In the first method for fabricating a semiconductor device, it is preferable that the conductive pattern contains Cu and the antioxidant layer contains CuO as a main component.

Thus, since an antioxidant layer containing CuO is passive, it prevents oxidation of 5 part of a conductive pattern located under the antioxidant layer. Therefore, it is possible to prevent the formation of a thick oxide film which is difficult to be removed. Accordingly, the antioxidant layer formed on the surface of the conductive layer can be removed in a simple manner.

In the first method for fabricating a semiconductor device, it is preferable that the 10 step of forming an antioxidant layer includes performing oxygen plasma treatment with a substrate temperature of 120 C° or less.

Thus, the proportion of CuO in an antioxidant layer formed on the surface of the conductive pattern is increased while the proportion of Cu<sub>2</sub>O therein is reduced. Accordingly, oxidation of the conductive pattern located under the antioxidant layer can be 15 further suppressed and thus the formation of a thick oxide film which is difficult to be removed on the surface of the conductive pattern can be reliably prevented. Therefore, the antioxidant layer formed on the surface of the conductive pattern can be removed in a more simple manner.

In the first method for fabricating a semiconductor device, it is preferable that the 20 step of forming an antioxidant layer includes performing oxygen plasma treatment with a chamber pressure of 40 Pa or less.

Thus, the proportion of CuO in an antioxidant layer formed on the surface of the conductive pattern is increased while the proportion of Cu<sub>2</sub>O therein is reduced. Accordingly, oxidation of the conductive pattern located under the antioxidant layer can be 25 further suppressed and thus the formation of a thick oxide film which is difficult to be

removed on the surface of the conductive pattern can be reliably prevented. Therefore, the antioxidant layer formed on the surface of the conductive pattern can be removed in a more simple manner.

A second method for fabricating a semiconductor device according to the present invention is characterized by comprising the steps of: forming an insulating film on a conductive pattern formed on a substrate; forming a resist pattern on the insulating film; performing etching to the insulating film using the resist pattern as a mask to form in the insulating film an opening at which part of the surface of the conductive pattern is exposed; forming an antioxidant layer on the part of the surface of the conductive pattern exposed; removing the resist pattern; and depositing a conductive film on the conductive pattern from which the antioxidant layer has been removed.

In the second method for fabricating a semiconductor device, an antioxidant layer is formed on the surface of a conductive pattern and then a resist pattern is removed. Thus, it is possible to prevent the progress of oxidation of the conductive pattern in removing the resist pattern and also to prevent the formation of a thick oxide film which is difficult to be removed. Moreover, the antioxidant layer formed on the surface of the conductive pattern can be removed in a simple manner, and thus it is possible to prevent an oxide film from being interposed between the conductive pattern and the conductive film. Therefore, the contact resistance between the conductive pattern and the conductive film can be reduced and variations in the contact resistance therebetween can be suppressed. Furthermore, the antioxidant layer has been formed on the surface of the conductive pattern before removing the resist pattern. Thus, the resist pattern can be removed in a short time.

In the second method for fabricating a semiconductor device, it is preferable that the conductive pattern contains Cu and the antioxidant layer contains CuO as a main component.

Thus, since an antioxidant layer containing CuO is passive, it prevents oxidation of part of a conductive pattern located under the antioxidant layer. Therefore, it is possible to prevent the formation of a thick oxide film which is difficult to be removed. Accordingly, the antioxidant layer formed on the surface of the conductive layer can be removed in a 5 simple manner.

In the second method for fabricating a semiconductor device, it is preferable that the step of removing the resist pattern includes performing oxygen plasma treatment with a substrate temperature of not less than 200 C° and not more than 250 C°.

Thus, a resist pattern can be removed in a short time.

10 In the second method for fabricating a semiconductor device, it is preferable that the step of forming an antioxidant layer includes performing oxygen plasma treatment with a first substrate temperature, and the step of removing the resist pattern includes performing oxygen plasma treatment with a second substrate temperature which is higher than the first substrate temperature.

15 Thus, it is possible to prevent the formation of a thick oxide film which is difficult to be removed and also to remove a resist pattern in a short time.

In the second method for fabricating a semiconductor device, it is preferable that the step of forming an antioxidant layer includes performing oxygen plasma treatment at a first pressure, and the step of removing the resist pattern includes performing oxygen 20 plasma treatment at a second pressure which is higher than the first pressure.

Thus, it is possible to prevent the formation of a thick oxide film which is difficult to be removed and also to remove a resist pattern in a short time.

In the second method for fabricating a semiconductor device, the step of forming an antioxidant layer includes performing reactive ion treatment to the conductive pattern, and 25 the step of forming a resist pattern includes performing oxygen plasma treatment.

Thus, it is possible to form an antioxidant layer and remove a resist pattern in a single chamber. Accordingly, an opening at which a conductive pattern is exposed is not exposed to the air, and therefore the progress of oxidation of the surface of the conductive pattern can be prevented.

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## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A through 1D shows cross-sectional views illustrating respective process steps for fabricating a semiconductor device according to the first embodiment of the present invention.

10 FIG. 2 a graph showing the XPS spectrum of the surface of a copper oxide layer according to the first embodiment.

FIG. 3 is a graph showing the relation between the ashing time and the thickness of a copper oxide layer in the first embodiment.

15 FIG. 4 is a graph showing the relation between the inside chamber pressure and the CuO generation ratio in the first embodiment.

FIG. 5 is a graph showing the relation between the substrate temperature and the CuO generation ratio in the first embodiment.

FIG. 6 is a graph showing the contact resistance in the semiconductor device of the first embodiment.

20 FIGS. 7A through 7E cross-sectional views illustrating respective process steps for fabricating a semiconductor device of the second embodiment of the present invention.

FIGS. 8A through 8D are cross-sectional views illustrating respective process steps for fabricating a known semiconductor device.

## 25 DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First Embodiment)

Hereinafter, a method for fabricating a semiconductor device according to a first embodiment of the present invention will be described with reference to the accompanying drawings.

FIGS. 1A through 1D are cross-sectional views illustrating respective process steps for fabricating a semiconductor device according to the first embodiment of the present invention.

First, as shown in FIG. 1A, a silicon oxide film 12 is formed on a semiconductor substrate 11 of silicon and then an interconnect groove is formed in the silicon oxide film 12. Next, a conductive pattern 13 of copper is formed so as to be filled in the interconnect groove formed in the silicon oxide film 12. Subsequently, an insulating film 14 is formed on the silicon oxide film 12 and the conductive pattern 13, and then a resist pattern 15 having an opening 15a is formed on the insulating film 14. Note that in this case, the conductive pattern 13 may be a lower interconnect or a plug.

Next, as shown in FIG. 1B, the insulating film 14 is etched by plasma dry etching using the resist pattern 15 as a mask to form an opening 14a in the insulating film 14. In this manner, the surface of the conductive pattern 13 is exposed. The plasma dry etching is performed using a parallel plate RIE system under the conditions where the flow rate of a CF<sub>4</sub> gas as an etching gas is 50 mL/min (normal state), the flow rate of an O<sub>2</sub> gas as a control gas for a deposit to be etched is 10 mL/min (normal state), the substrate temperature is 25 C°, the RF output power is 1000 W, and the inside chamber pressure is 5 Pa.

Next, as shown in FIG. 1C, ashing using an oxygen gas is performed to remove the resist pattern 15. The ashing is performed using a microwave plasma ashing system under the conditions where the flow rate of an oxygen gas is 300 mL/min (normal state), the

microwave output power is 2000 W, the discharge time is about 3 minutes, the substrate temperature is about 25 C° and the pressure is about 5 Pa. By this ashing, the resist pattern 15 is removed and a copper oxide layer 13a which has a thickness of about 5 nm and serves as an antioxidant layer is formed on part of the surface of the conductive film 13

5 exposed. Details of the copper oxide layer 13a will be described later.

Next, as shown in FIG. 1D, the copper oxide layer 13a which has been formed during the ashing is removed by cleaning using an organic acid cleaning agent containing ammonium fluoride, and Ar sputtering. Thereafter, a conductive film 16 of copper is formed on part of the conductive pattern 13 from which the copper oxide layer 13a has

10 been removed and the insulating film 14. Then, although not shown in FIG. 1D, as many conductive films as necessary are formed one by one, and furthermore a passivation film and the like are formed. Thus, a semiconductor device is completed.

Now, the copper oxide layer 13a formed during the ashing as shown in FIG. 1C will be specifically described.

15 First, differences in composition between the copper oxide layer 13a formed in the first embodiment of the present invention and the copper oxide layer 103a formed in the method for fabricating the known semiconductor device will be described.

FIG. 2 is a graph showing the XPS spectrum of surface of the copper oxide layer 13a from which the resist pattern 15 has been removed by ashing. Note that in FIG. 2, the

20 abscissa indicates binding energy and the ordinate indicates relative intensity.

In general, oxidized forms of Cu include a form represented by Cu<sub>2</sub>O where the copper and oxygen ratio is 1:2 and a form represented by CuO where the copper and oxygen ratio is 1:1.

As in the known example, when ashing is performed at high temperature and high

25 pressure to remove the resist pattern 105, the known copper oxide layer 103a containing

$\text{Cu}_2\text{O}$  as a main component is formed as indicated by the bottom line (a) of FIG. 2. On the other hand, as in the first embodiment of the present invention, when ashing is performed at a low temperature or a low pressure to remove the resist pattern 15, the copper oxide layer 13a containing  $\text{CuO}$  as a main component is formed as indicated by the upper line (b) 5 of FIG. 2.

The reason why the compositions of the copper oxide layer 13a of this embodiment and the copper oxide layer 103a of the known example are different is as follows. At high temperature and high pressure, Cu undergoes a thermal reaction to be oxidized and thus  $\text{Cu}_2\text{O}$ , which lacks oxygen, is mainly generated. At a low temperature or a low pressure, in 10 contrast, the semiconductor substrate 11 and a ground are coupled and thereby oxygen ions are forcibly implanted into the surface of the conductive pattern 13. Thus, oxygen rich  $\text{CuO}$  is mainly generated on the surface of the conductive pattern 13.

Next, differences in thickness between the copper oxide layer 13a formed in the first embodiment of the present invention and the copper oxide layer 103a formed in the 15 method for fabricating a known semiconductor device due to differences between their components will be described.

FIG. 3 is a graph showing the relation between the ashing time and the thickness of a copper oxide layer in this embodiment.

As shown in FIG. 3, as for the copper oxide layer 103a containing as a main 20 component  $\text{Cu}_2\text{O}$  formed in the method for fabricating the known semiconductor device, the film thickness increases as the ashing time increases.

In contrast, as for the copper oxide layer 13a containing  $\text{CuO}$  as a main component and formed in the present invention, the following fact has been confirmed. As shown in FIG. 3, immediately after the start of the ashing, Cu contained in the conductive pattern 13 25 is oxidized and then  $\text{CuO}$  with a thickness of about 5 nm is generated, so that the copper

oxide layer **13a** containing CuO is formed. Thereafter, even though the ashing is continuously performed, oxidation does not further proceed. This is because the copper oxide layer **13a** containing CuO as a main component is passive and functions as an antioxidant layer for preventing the progress of oxidation of the conductive pattern **13** under the copper oxide layer **13a**. As has been described, the progress of the oxidation is prevented and thus the copper oxide layer **13a** is kept thin. Therefore, the copper oxide layer **13a** can be removed in a simple manner by cleaning using an organic acid agent containing ammonium fluoride, and Ar sputtering.

FIG. 4 is a graph showing the relation between the pressure of inside of a chamber during ashing and the generation ratio of CuO to the entire copper oxide formed by the ashing.

As shown in FIG. 4, when the inside chamber pressure is over 40 Pa, oxygen ions are scattered and thus the kinetic energy of oxygen ions is reduced. Accordingly, the amount of implanted oxygen ions into the surface of the conductive pattern **13** is reduced. Thus, the generation ratio of CuO to the entire copper oxide is low. On the other hand, when the inside chamber pressure is 40 Pa or less, the generation ratio of CuO to the entire copper oxide is high. Note that the preferable lower limit of the inside chamber pressure is not particularly limited. However, with the inside chamber pressure of 1 Pa or more, the resist pattern **15** can be sufficiently removed by ashing. Therefore, it is more preferable that the inside chamber pressure is 1 Pa or more.

FIG. 5 is a graph showing the relation between the substrate temperature and the generation ratio of CuO to the entire copper oxide formed by ashing.

As shown in FIG. 5, the substrate temperature is over 120 C°, a thermal reaction is accelerated. Accordingly, Cu<sub>2</sub>O is rapidly generated and therefore the generation ratio of CuO to the entire copper oxide becomes low. On the other hand, when the substrate

temperature is 120 C° or less, the generation ratio of Cu to the entire copper oxide is high. Note that the preferable lower limit of the substrate temperature is not particularly limited. However, it is more preferable that the substrate temperature is 0 C° or more in order to avoid making a semiconductor device complicated.

5 As has been described, it has been clearly shown by FIGS. 4 and 5 that if ashing is performed with a substrate temperature of 120 C° or less or with an inside chamber pressure of 40 Pa or less, the proportion of CuO in the copper oxide layer 13a as an antioxidant layer formed on the conductive pattern 13 is increased while the proportion of Cu<sub>2</sub>O generated on the surface of the conductive pattern 13 is reduced. Accordingly, the  
10 oxidation of the conductive pattern 13 can be further suppressed and thus the formation of a thick oxide film which is difficult to be removed on the surface of the conductive pattern 13 can be reliably prevented. Therefore, the antioxidant layer formed on the surface of the conductive pattern 13 can be removed in a more simple manner.

FIG. 6 is a graph showing the contact resistances in the semiconductor device of  
15 this embodiment and the semiconductor device of the known example. More specifically,  
FIG. 6 shows measured values of contact resistance for fifteen contacts between the  
conductive pattern 13 and the conductive layer 16 of this embodiment and for fifteen  
contacts between the conductive pattern 103 and the conductive layer 106 of the known  
example.  
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As is evident from FIG. 6, compared to the measured values of contact resistance  
for fifteen contacts between the conductive pattern 103 and the conductive layer 106 of the  
known example, the measured values of contact resistance for fifteen contacts between the  
conductive pattern 13 and the conductive layer 16 of this embodiment are largely reduced  
and variations among the values are also reduced.

Note that in the known example, ashing is performed to the resist pattern **105** at high temperature and high pressure because a time required for removal of the resist pattern **105** by the ashing is intended to be reduced. These temperature and pressure conditions are considered to be proper to be adopted in order to achieve original purpose of  
5 ashing.

On the other hand, in the first embodiment of the present invention, ashing is performed to the resist pattern **15** at a low temperature or a low pressure. Only in view of the purpose of removing the resist pattern **15**, these temperature and pressure conditions are not usually adopted because such conditions will cause a reduction in throughput.  
10 However, if ashing is performed to the resist pattern **15** at a low temperature or a low pressure, the copper oxide layer **13a** which contains CuO as a main component and functions as an antioxidant layer can be formed on the surface of the conductive pattern **13**. The copper oxide layer **13a** containing CuO as a main component can be removed in a simple manner. Thus, by forming the conductor film **16** after the copper oxide layer **13a**  
15 has been removed, the noticeable effect of largely reducing the contact resistance between the conductive pattern **16** and the conductive film **16** can be achieved.

Note that by using a microwave plasma ashing system in performing ashing to the resist pattern **15**, the ion bombardment effect due to coupling between the semiconductor substrate **11** and the ground is utilized as has been described using FIG. **1C**. However,  
20 even when some other ashing apparatus is used, the same effects can be attained. It is supposed that if a bias-power applying type system in which ion energy can be controlled is used, the contact resistance between the conductive pattern **13** and the conductive film **16** can be further reduced and variations in the contact resistance therebetween can be further reduced.

As has been described, in the first embodiment, the copper oxide layer **13a** as an antioxidant layer for preventing the conductive pattern **13** from being oxidized is formed on the surface of the conductive pattern **13** while the resist pattern **15** is removed by ashing. Thus, it is possible to prevent the progress of oxidation of the conductive pattern **13** in removing the resist pattern **15** and also to prevent the formation of a thick oxide film which is difficult to be removed on the surface of the conductive pattern **13**. Moreover, the copper oxide layer **13a** formed on the surface of the conductive pattern **13** can be removed in a simple manner, and thus it is possible to prevent an oxide film from being interposed between the conductive pattern **13** and the conductive film **16**. Therefore, the contact resistance between the conductive pattern **13** and the conductive film **16** can be reduced and variations in the contact resistance therebetween can be suppressed.

(Second Embodiment)

Hereinafter, a method for fabricating a semiconductor device according to a second embodiment of the present invention will be described with reference to the accompanying drawings.

FIGS. 7A through 7E are cross-sectional views illustrating respective process steps for fabricating a semiconductor device of the second embodiment of the present invention.

Differences between the methods for fabricating a semiconductor device according to the second embodiment and the above-described first embodiment will be described. In the fabrication method of the first embodiment, as has been described, the copper oxide layer **13a** is formed and the resist pattern **15** is removed in the same process step. However, in the fabrication method of the second embodiment, as will be described later, a copper oxide layer **23a** (which will be described later) is formed and a resist pattern **25**

(which will be described later) is removed separately in different process steps. A specific description is as follows.

First, as shown in FIG. 7A, a silicon oxide film 22 is formed on a semiconductor substrate 21 of silicon and then an interconnect groove is formed in the silicon oxide film 22. Next, a conductive pattern 23 of copper is formed so as to be filled in the interconnect groove formed in the silicon oxide film 22. Subsequently, an insulating film 24 is formed on the silicon oxide film 22 and the conductive pattern 23, and then a resist pattern 25 having an opening 25a is formed on the insulating film 24. Note that in this case, the conductive pattern 23 may be a lower interconnect or a plug.

Next, as shown in FIG. 7B, the insulating film 24 is etched by plasma dry etching using the resist pattern 25 as a mask to form an opening 24a in the insulating film 24. In this manner, the surface of the conductive pattern 23 is exposed. The plasma dry etching is performed using a parallel plate RIE system under the conditions where the flow rate of a CF<sub>4</sub> gas as an etching gas is 50 mL/min (normal state), the flow rate of an O<sub>2</sub> gas as a control gas for a deposit to be etched is 10 mL/min (normal state), the substrate temperature is 25 C°, the RF output power is 1000 W, and the inside chamber pressure is 5 Pa.

Next, as shown in FIG. 7C, continuously using the parallel plate RIE system which has been used in the plasma dry etching, oxygen plasma treatment is performed in the same chamber under the conditions where the flow rate of an oxygen gas is about 300 mL/min (normal state), the RF output power is 200 W, the discharge time is about 10 seconds, the substrate temperature is 25 C° and the pressure is about 5 Pa. Thus, a copper oxide layer 23a which contains CuO as a main component, has a thickness of about 5 nm, and serves as an antioxidant layer is formed on the surface of the conductive film 23. As has been described, the oxygen plasma treatment is performed in the same chamber, and thus the

opening **24a** at which the conductive pattern **23** is exposed is not exposed to the air. Accordingly, oxidation of the surface of the conductive pattern **23** can be prevented. Moreover, since the copper oxide layer **23a** is passive, the thickness of the copper oxide layer **23a** is not increased any more like the copper oxide layer **13a** in the first 5 embodiment.

Next, as shown in FIG. 7D, ashing using an oxygen gas is performed to remove the resist pattern **25**. The ashing is performed using a microwave plasma ashing system under the conditions where the flow rate of an oxygen gas is 1000 mL/min (normal state), the microwave output power is 2000 W, the substrate temperature is about 250 C° and the 10 pressure is about 100 Pa. As has been described, unlike the first embodiment, since the copper oxide layer **23a** as an antioxidant layer has been formed before the resist pattern is removed by ashing, the resist pattern **25** is removed by performing ashing at high temperature and high pressure. Thus, the discharge time can be reduced to about 1 minute. Note that the plasma treatment is preferably performed with the substrate temperature of 15 not less than 200 C° and not more than 250 C°.

Next, as shown in FIG. 7E, the copper oxide layer **23a** is removed by cleaning using an organic acid cleaning agent containing ammonium fluoride, and Ar sputtering. Thereafter, a conductive film **26** of copper is formed on part of the conductive pattern **23** from which the copper oxide layer **23a** has been removed and the insulating film **24**. Then, 20 although not shown in FIG. 7E, as many conductive films as necessary are formed one by one, and furthermore a passivation film and the like are formed. Thus, a semiconductor device is completed.

As has been described, in the second embodiment, the copper oxide layer **23a** as an antioxidant layer for preventing oxidation of the conductive pattern **23** is formed on the 25 surface of the conductive pattern **23**. Thus, it is possible to prevent the progress of

oxidation of the conductive pattern **23** in removing the resist pattern **25** and also to prevent the formation of a thick oxide film which is difficult to be removed on the surface of the conductive pattern **23**. Moreover, the copper oxide layer **23a** formed on the surface of the conductive pattern **23** can be removed in a simple manner, and thus it is possible to prevent  
5 an oxide film from being interposed between the conductive pattern **23** and the conductive film **26**. Therefore, the contact resistance between the conductive pattern **23** and the conductive film **26** can be reduced and variations in the contact resistance therebetween can be suppressed. Furthermore, the copper oxide layer **23a** has been formed on the surface of the conductive pattern **23** before removing the resist pattern **25**. Thus, the resist  
10 pattern **25** can be removed at high throughput by ashing at high temperature and high pressure.

Note that in the second embodiment, the case where a parallel plate RIE system is used as a means for forming on the surface of the conductive pattern **23** the copper oxide layer **23a** containing CuO as a main component and serving as an antioxidant layer has  
15 been described. However, as in the first embodiment, an ashing system may be used to form the copper oxide layer **23a** at a low temperature or a high pressure. In such a case, by operating an ashing system at high temperature and high pressure after an antioxidant layer has been formed on the surface of the conductive pattern **23**, ashing to the resist pattern **25** can be finished in a short time.